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AIRCRAFT ANTI-ICING/DE-ICING.(U)
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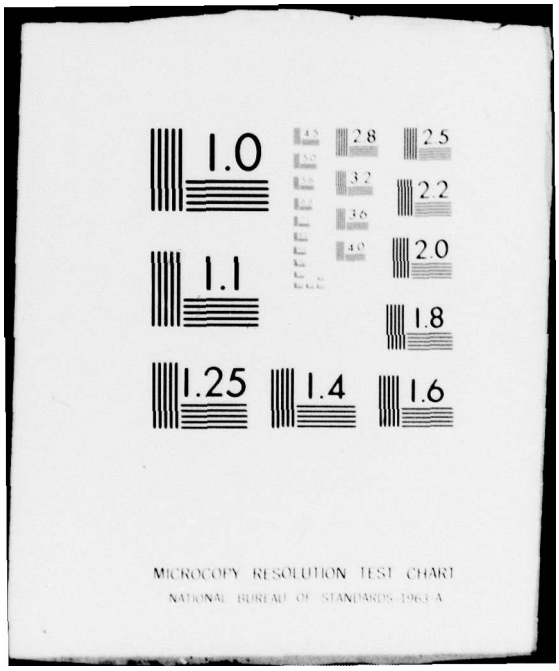
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Anti-Icing System
De-Icing System
Antifreeze fluids
Pneumatically Operated Boot
Conducted Heat
Ice Shedding Characteristics

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document provides information, methodology and techniques necessary to plan, conduct and document a development test of an aircraft anti-icing/de-icing system. A development test of an aircraft anti-icing/de-icing system will determine the degree to which a subject system and its associated documentation, tools and auxiliary equipment meets the requirements of the Army Materiel Needs ~~(MN's)~~ documents.

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(14) TOP-7-3-528

US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURES

(9) Final rept. on test operating procedure.

DRSTE-RP-702-106
*Test Operations Procedures 7-3-528
AD No.

(11) 31 August 1979

(12) 21p.

(6) AIRCRAFT ANTI-ICING/DE-ICING

1. SCOPE. This TOP covers the procedures for testing and evaluating aircraft anti-icing/de-icing equipment. In particular, anti-icing/de-icing equipment is designed to prevent ice buildup and to shed any ice accumulation that has occurred prior to equipment operation on critical aircraft areas such as lift and control surfaces, pitot tube, and air inlet surfaces, etc. This equipment utilizes antifreeze fluids, mechanical forces and thermal energy, operating separately or in combination to accomplish the anti-icing/de-icing function. Normally, the anti-icing or ice prevention is accomplished by applying antifreeze fluids and/or conducting heat to the critical area. De-icing or ice removal is normally accomplished by means of a mechanical and/or thermal system which sheds ice formation through the use of pneumatically operated boots and/or conducted heat. The scope of this document is sufficiently broad and the test procedures, by design, are general to accommodate testing of new anti-icing/de-icing technology and redesign of existing

*This TOP supersedes MTP 7-3-528, 24 March 1971.

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equipment due to changes in aircraft configuration and tactical operations. Test will be conducted in aircraft equipped with anti-icing/de-icing equipment under actual and/or simulated weather conditions conducive to accomplishing the test objectives.

2. FACILITY AND SUPPORT REQUIREMENTS. Developmental test of an aircraft anti-icing/de-icing system or specific equipment will be conducted in an environment, simulated or natural, conducive to ice formation and accumulation on the critical aircraft surface areas under consideration. In an induced environment test, the aircraft flight characteristics must be considered, and the relative movement of the aircraft through the simulated air mass must be realistic when compared to aircraft flight through the natural environment. The facility and major support equipment required to support the developmental test should be defined in the Test Design Plan or Maintenance Support Plan; however, if this data is not available, the following facility characteristics and support requirements should be addressed as a minimum to support the evaluation of all developmental criteria presented in the appropriate developmental materiel documents: Materiel Needs document, Letter of Requirement (LR), Letter of Agreement (LOA), Required Operational Characteristics (ROC).

2.1 Facility.

CHARACTERISTICS	MINIMUM REQUIRED
Appropriate operational airfields	Within range of appropriate icing weather conditions.
Appropriate air space	As required.
Simulation facility	Climatic chamber, as applicable.

2.2 Equipment and Support.

Installation equipment	Standard tool set.
Photographic equipment	Black and white camera.
Time measuring device	Stop watch.

Equipment and Support.

CHARACTERISTICS	MINIMUM REQUIRED
Aircraft maintenance support	As required.
Aircraft operational support equipment	Standard unit support equipment.
Appropriate type and configuration aircraft.	See Materiel Needs documents (LR, LOA, ROC).
Equipment to measure environment conditions	As appropriate.
Test personnel	Aircraft crew(s), data collection and processing personnel, maintenance and logistics personnel.
Test personnel equipment	Applicable cold weather gear.

2.3 References.

a. Army Regulation 385-16, Systems Safety.

b. Army Regulation 750-1, w/TECOM Supplement 1, Army Materiel Maintenance Concepts and Policies.

c. Army Regulation 750-6, Maintenance of Supplies and Equipment: Maintenance Support Planning.

d. Army Regulation 70-62, Airworthiness Qualification of Army Aircraft Systems.

e. AMC Regulation 70-8, w/TECOM Supplement 1, DARCOM Value Engineering Program.

f. AMC Regulation 385-12, w/TECOM Supplement 1, Life Cycle Verification of Materiel Safety.

g. AMC Regulation 700-38, w/TECOM Supplement 1 and USAADTA Supplement 1, Test and Evaluation -- Incidents Disclosed During Materiel Testing.

h. TECOM Regulation 70-24, Research and Development: Documenting Test Plans and Reports.

i. TECOM Regulation 108-2, Photographic Coverage. (As implemented by USAADTA Memo 108-1).

j. TECOM Regulation 385-7, Potential Health Hazards to Humans Participating in Testing.

k. MIL-STD-129, Marking for Shipment and Storage.

l. MIL-STD-130, Identification Marking of US Military Property.

m. MIL-STD-882, System Safety Program Requirements.

n. MIL-A-9482, Anti-icing Equipment for Aircraft, Heated Surface Type, General Specification for.

o. MIL-D-8804, De-icing System, Pneumatic Boot, Aircraft, General Specification for.

p. MIL-D-38453, Environmental Control, Environmental Protection, and Engine Bleed Air Systems; Aircraft and Aircraft Launched Missiles, General Specification for.

q. TOP 1-2-609, Instructional Material Adequacy Guide and Evaluation Standard (IMAGES).

r. TOP 1-2-610, Human Factors Engineering.

s. TOP 7-3-500, Physical Characteristics.

t. TOP 7-3-501, Personnel Training.

u. TOP 7-3-502, Installation Characteristics.

v. TOP 7-3-503, Arrival Inspection/Pre-Operational Inspection (Aviation Materiel).

w. TOP 7-3-506, Safety.

x. TOP 7-3-507, Maintenance (Maintainability/Availability).

y. TOP 7-3-508, Reliability.

z. TOP 7-3-509, Compatibility with Related Equipment.

aa. TOP 7-3-519, Photographic Coverage.

bb. TOP 7-3-530, Vulnerability and Security (Aviation Materiel).

cc. Materiel Needs documents (LR, LOA, ROC).

3. PREPARATION FOR TEST. This section provides guidance for planning the developmental test. The planning phase should consummate with a detailed test plan. The test plan should establish the test methodology and provide the procedures for gathering and reducing data to accommodate each developmental test objective. The test plan should also identify all facility, equipment and support requirements including any specialized training requirements. The following test planning steps should be followed to insure a complete, thorough and cost effective developmental test.

3.1 Review. Review all pertinent data relative to the materiel development test.

a. Materiel Needs documents (LR, LOA, ROC).

b. Test Design Plan.

c. Applicable material available from the developer.

d. Pertinent reports on previous tests of like equipment.

e. Any other applicable sources of information (AR, TOPs, TM, etc.).

3.2 Test Objectives. Establish the test objectives. The test objectives should be available in the Test Design Plan; however, if this data is not available, the test agency should coordinate with TECOM Headquarters and the materiel proponent when establishing objectives or review the Materiel Needs documents for developmental criteria and consider the following subtest objectives as a minimum:

a. Initial Inspection: Determine the condition and completeness of the anti-icing/de-icing equipment in accordance with TOP 7-3-503.[1]

b. Physical Characteristics. Determine the physical characteristics of the anti-icing equipment in accordance with TOP 7-3-500.[2]

c. Installation Characteristics. Determine the installation/removal characteristics of the anti-icing/de-icing equipment in accordance with TOP 7-3-503.[3]

d. Compatibility. Determine if the anti-icing/de-icing equipment is compatible with the designated aircraft for which it was designed during all applicable phases of aircraft operation, in accordance with TOP 7-3-509.[4] Electrical power requirements are of particular importance and should be accurately determined for each operational mode.

e. Operational Performance. Determine the operational capability of the de-icing/anti-icing system and assess the adequacy of the system to perform its intended function under all applicable operational environmental conditions and flight modes. Follow the testing procedures as presented in paragraph 5, Performance Test, this TOP. The hazard of possible ice ingestion into the engine and aircraft damage caused by the shedding of ice from the critical areas will be addressed.

f. Reliability, Availability and Maintainability (RAM). Evaluate the RAM characteristics of the developmental de-icing/anti-icing equipment in accordance with TOP 7-3-507[5] and TOP 7-3-508.[6]

1. TOP 7-3-503, Arrival Inspection/Pre-Operational Inspection (Aviation Materiel).
2. TOP 7-3-500, Physical Characteristics.
3. TOP 7-3-503, Arrival Inspection/Pre-Operational Inspection (Aviation Materiel).
4. TOP 7-3-509, Compatibility with Related Equipment.
5. TOP 7-3-507, Maintenance (Maintainability/Availability).
6. TOP 7-3-508, Reliability.

g. Technical Manuals. Determine the adequacy of the technical manuals in accordance with TOP 1-2-609.[7]

h. Personnel Training Requirements. Determine the scope of the pre-developmental test and field training required to operate and maintain the de-icing/anti-icing equipment, in accordance with TOP 7-3-501.[8]

i. Human Factors. Determine if the de-icing/anti-icing equipment meets with acceptable human factors engineering, in accordance with TOP 1-2-610.[9]

j. Safety. Identify and evaluate the severity and probability of occurrence of safety or health hazard, operational or maintenance characteristics in accordance with TOP 7-3-506[10] and TECR 385-7.[11]

3.3 Schedule. Prepare a detailed test timeline depicting each test associated event which must occur to insure availability of required support equipment, facilities, logistics and personnel to accomplish a comprehensive and cost effective test. An adequate timeline will show sufficient time periods allotted to accomplish each test objective insuring that an adequate amount of test data are taken to provide projected statistical confidences when the data is reduced. The following schedule items should be addressed as a minimum.

a. Facility. Schedule the applicable facility requirements presented in Section 2.1. These are long lead time items and should be scheduled well in advance of occupancy requirement.

b. Equipment and Support. Schedule the applicable instrumentation, equipment and support requirements presented in Section 2.2.

c. Logistics. Schedule logistics requirements including ground handling equipment, administrative transportation of both personnel and equipment, aircraft fueling and servicing accommodations.

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7. TOP 1-2-609, Instructional Material Adequacy Guide and Evaluation Standard (IMAGES).
8. TOP 7-3-501, Personnel Training.
9. TOP 1-2-610, Human Factors Engineering.
10. TOP 7-3-506, Safety.
11. TECOM Regulation 385.7, Potential Health Hazards to Humans Participating in Testing.

3.4 Plan of Test. Develop a detailed test plan in accordance with TECOM Regulation 70-24.[12] This test plan will provide the test procedures to be followed and the test data collection requirements to satisfy the test objectives.

3.5 Safety. Develop adequate safety and health measures for the protection of test participants and equipment. Take appropriate steps (SOP, Safety checklist, and informing participants of potential hazards and protective measures) to insure that test participants are not exposed to risk beyond normal duty limits. Obtain airworthiness qualification for rest of equipment installed on aircraft to be flown, in accordance with AR 70-62.[13]

3.6 Environmental Impact. Determine if there are any environmental considerations. If environmental hazards exist, develop procedures or outline precautions to be observed to protect the environment.

3.7 Human Factors Engineering. Insure good human factors engineering practices are planned into the test when conducted by qualified personnel in the induced test environment. The major considerations should be in the areas of test personnel safety, physiological functions and test conduct efficiency. See TOP 1-2-610.[14]

3.8 Security. Security safeguards for the United States Government and for the security of the proprietary rights of the test materiel developer must be considered early in the test planning stage. The following steps must be taken:

a. Consult the primary test agency security representative for security guidance. Coordinate with security personnel of other test support agencies and industry as appropriate.

b. Take appropriate security measures throughout the test to safeguard intra-industry proprietory and classified material and to safeguard the security of government property.

c. See TOP 7-3-530, Vulnerability and Security (Aviation Materiel).[15]

12. TECOM Regulation 70-24, Research and Development: Documenting Test Plans and Reports.
13. Army Regulation 70-62, Airworthiness Qualification of Army Aircraft Systems.
14. TOP 1-2-610, Human Factors Engineering.
15. TOP 7-3-530, Vulnerability and Security (Aviation Materiel).

4. TEST CONTROLS. The de-icing/anti-icing equipment test will be conducted and test data will be recorded in strict compliance with the Test Design Plan. If specific directions are not available, the following guidelines will prevail:

a. Measurement units will be reported in the universal metric and English system.

b. Numerical observations will be rounded up to the nearest hundredth.

c. Time will be reported to the nearest hundredth of an hour.

d. Physical characteristics will be accomplished and recorded in compliance with TOP 7-3-500.[16]

e. Instrumentation and equipment will be properly calibrated and have a current calibration certificate.

f. All tests will be conducted and data collected in compliance with prescribed and/or standard procedures and when deviations are required, justification will be documented.

g. All data will be recorded and processed in a timely fashion.

h. Only properly trained and qualified personnel will participate in the conduct of the test.

i. The de-icing/anti-icing equipment test will be conducted only in a test environment representative of the operational environment intended for the materiel use.

j. Each test run will be conducted under documented conditions, such that the test results could be duplicated or compared.

k. The detailed test plan will be followed; the test agency will give prior notification to TECOM HQ when deviating significantly from approved detailed test plan.

16. TOP 7-3-500, Physical Characteristics (Aviation Materiel).

5. PERFORMANCE TESTS.

a. The experience and qualifications of test personnel will be recorded on the data forms provided at Appendix C. This record of test personnel data will be utilized to assess the experience and qualifications of personnel assigned to participate in the test. Each key individual will be assigned an identification letter in parenthesis which will tag their contributions in completing any qualitative assessment required in the data collection and presentation. Individual names will not be presented in the test report in order to preserve individual privacy.

b. The conduct of the development test shall be performed in compliance with the Test Design Plan reflected through the detailed test plan. However, if specific guidance is not available in the Test Design Plan, the test plan will reflect the following criteria and methodology to conduct the developmental performance test of the de-icing/anti-icing equipment. The operational performance of the anti-icing/de-icing equipment shall be evaluated during inclement weather at temperatures conducive to ice formation. Evaluations shall be conducted during ground operations, with and without engines running, and during transient and steady flight operations with aircraft flying at different speeds within the limitations of the aircraft.

5.1 Ground Operation. Evaluate the operation of the anti-icing/de-icing equipment to eliminate any accumulated ice present on the applicable aircraft areas and to maintain areas free of ice buildup.

5.1.1 Engine Off Auxiliary Power.

5.1.1.1 Method. Make provisions to measure the ice buildup on the critical aircraft areas under consideration and to monitor the atmospheric climatic condition during the ice buildup and ice elimination test phases. Perform the following test procedures:

a. Record the atmospheric climatic conditions throughout each test run.

b. Record the ice buildup depth and approximate area of ice coverage; photograph liberally.

c. Determine the ice buildup composition (clear, rime, etc.).

d. Adjust the de-icing control to optimum operation and record the time required to eliminate ice on the appropriate surfaces.

e. Note the approximate size and location from which large chunks of ice are shed.

f. Adjust the anti-icing control to normal operating setting and determine the adequacy of the system to maintain the appropriate areas clear of ice buildup.

g. Record the power (volts and amps) versus time to operate the system for each operating control setting.

h. Repeat the above procedures varying the control setting toward the minimum and maximum operating settings.

5.1.1.2 Data Required.

a. Time history of the following parameters:

(1) Temperature.

(2) Barometric pressure.

(3) Precipitation, rate, state, consistency.

(4) Humidity.

(5) Wind condition relative to appropriate aircraft surface areas under consideration.

(6) Ice buildup.

b. Final ice buildup depth and approximate area of ice coverage. Photograph as appropriate.

c. Type and consistency of ice buildup (clear, rime, powdery, sluggish, etc.).

d. Control setting and time required to clear ice buildup for each test run.

e. Ice shed characteristics as applicable.

f. Power timeline (volts, amps) to operate the anti-icing/de-icing equipment for each test run.

g. Incidence of unusual vibrations of main and tail rotors of rotary wing aircraft.

h. Amount of anti-icing fluid should be recorded if used.

i. Pulse rate and air pressure of pneumatically operated de-icing boots.

5.1.2 Engine On Internal Power. As appropriate, make the necessary tie-down precautions and repeat the procedures presented in paragraph 5.1.1.1, Method. Collect data as required by paragraph 5.1.1.2.

5.2 Airborne Operations. Evaluate the operation of the anti-icing/de-icing equipment to prevent ice buildup when flying in areas of known icing conditions and to shed ice buildup allowed to accumulate under very controlled conditions with maximum safety precautions. Take into account the ice shedding characteristics observed in the non-flying test of the equipment and establish safety procedures and precautions to evaluate the possibility of aircraft damage due to shedding of ice. Perform the evaluation under transient (climb, dive, turns, accelerations) and steady state flight conditions at minimum and maximum airspeeds as appropriate.

5.2.1 Method. Make provisions to measure the ice buildup on the critical aircraft areas under consideration. This can be done through still or motion picture techniques, focused on calibrated markers. Monitor the atmospheric climatic conditions during the ice buildup and elimination test phases. Perform the following test procedures:

a. Record the atmospheric climatic conditions throughout the test run.

b. Record the ice buildup depth and approximate area of ice coverage. (Photograph liberally, if practical.)

c. Determine the type and consistency of ice buildup (clear, rime, etc.) as practical.

d. Establish a flight profile (ascent, descent, turn, acceleration, etc.) and adjust the de-icing control to optimum operation and record the time required to eliminate ice buildup on the appropriate surfaces.

e. Photograph when possible and note approximate size and location from which large chunks of ice are shed. Photograph if possible and note the trajectory of the ice shed with respect to critical aircraft structure and components which might sustain damage. Record visual and audio indications of ice strikes. Make sure aircraft engine is equipped with air intake screen or particle separator to avoid foreign object damage to the engine. (NOTE: Refer to Operatior's Manual as to installation of air inlet screen during icing conditions.)

f. Adjust the anti-icing controls to normal operating setting and determine the adequacy of the system to maintain the appropriate areas clear of ice buildup.

g. Record the power (volts, amps) versus time to operate the system for each operating control setting.

h. Repeat the above procedures varying the control settings as appropriate toward the minimum and maximum operational settings.

5.2.2 Data Required.

a. Time history of the following parameters:

(1) Temperature.

(2) Barometric pressure.

(3) Precipitation.

(4) Humidity.

(5) Altitude.

(6) Airspeed.

(7) Ice buildup.

b. Final ice buildup depth and approximate area of ice coverage. Photograph if practical.

c. Type and consistency of ice buildup (clear, rime, powdery, sluggish, etc.).

d. Control setting, flight profile flown and time required to clear ice buildup for each test run.

e. Ice shedding and trajectory characteristics; photograph still and moving, as practical.

6. DATA REDUCTION AND PRESENTATION. Organization of test data is a major part of the data reduction process and should be considered early in the test planning stages. Early identification of the data parameters required, data source availability, and data collection technique to be used are the key to a complete and well organized data set for each test phase. This early planning and the continual process of data identification and correlation as to time, parameter grouping, test run and test objective are essential to a smooth running test, a complete and accurate data analysis, and a successful presentation/documentation.

6.1 Data Reduction. Data reduction in general involves the processing of raw data which consists of organizing, identifying, and correlating test data as to time, parameters and test run. As required, test data measurement units will be converted and analytical analysis performed to satisfy the test objective and verify compliance or noncompliance with the test criteria or specifications.

6.2 Data Presentation.

a. A composite documentation of the reduced and correlated data arranged normally by test phase in the general form of a narrative description supported by diagrams, graphs, photographs and tabular data as required. It should be clearly evident, with supportive data, the degree to which the anti-icing/de-icing equipment satisfies the test criterion and equipment specifications.

b. In the instance of a total or partial failure of the test item to perform its intended function, assess the broad implications of the failure to the developmental equipment itself and to the operational mission objective.

c. Summarize the test results and present any instance where the anti-icing/de-icing equipment failed to meet the test criteria or equipment design specifications.

d. Provide, when possible, recommendations for solutions to any problems encountered.

Recommended changes to this publication should be forwarded to Commander, US Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, MD 21005. Technical information may be obtained from the preparing activity: Commander, US Army Aviation Development Test Activity, ATTN: STEBG-QA, Fort Rucker, AL 36362. Additional copies are available from the Defense Documentation Center, Cameron Station, Alexandria, VA 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A

CHECKLIST

Anti-Icing/De-Icing Equipment

	YES	NO
1. Has developmental testing been completed in accordance with the appropriate TOP presented for each subtest presented in paragraph 3.2(a-j)?		
2. Were all test objectives presented in paragraph 3.2(a-j) addressed and, if not accomplished, adequately explained?		
3. Were the test facilities and other accommodations and support equipment sufficient to accomplish the test?		
4. Were the test results compromised in any way due to insufficient test preparation?		
5. Were the test results compromised in any way due to test control procedures?		
6. Were the test results compromised in any way due to performance test procedures?		
7. Were the test results compromised in any way due to data gathering, reduction or presentation techniques?		
8. Have all data collected been reviewed for correctness and completeness?		
9. Have performance data been collected, recorded and presented in accordance with this TOP 7-3-528?		

	YES	NO
10. Have all data forms in Appendix B of all appropriate TOPs presented in paragraph 3.2(a-j) been completed and reviewed for inclusion into the final test report?		

APPENDIX B

DATA COLLECTION FORM

Aircraft Anti-Icing/De-Icing

1. Anti-icing/de-icing equipment identification_____.

   a. Aircraft type/configuration_____.

   b. Critical aircraft area(s) under consideration_____.

   c. Test run_____Power supply_____Flight mode_____.

   d. Atmospheric/Meteorology data. Time Correlated

   (1) Time _____

   (2) Temperature _____

   (3) Barometric Pressure _____

   (4) Humidity _____

   e. Ice buildup characteristics.

   (1) Rate (per hour)

   (2) Precipitation composition (snow, sleet, rain, etc.)_____

   (3) Ice composition (clear, rime, etc.)_____

   f. Aircraft altitude versus time. _____

   g. Airspeed versus time. _____

NOTE: Place personnel identification code from Appendix C, by each response to the Data Collection Form, this Appendix, as appropriate.

h. Ice buildup versus time. _____

i. Time required to eliminate ice buildup. _____

j. Equipment control setting. _____

k. Power requirements versus time.

(1) Amps. _____

(2) Volts. _____

l. Qualitative assessment.

(1) Assess overall operating characteristics.

_____

_____

_____.

(2) Assess possible hazards of ice shedding characteristics and record any other safety or health hazards observed.

_____

_____

_____.

(3) Discuss the capability of the anti-icing equipment to prevent formation of ice on appropriate aircraft, critical areas, during operation in critical icing atmospheric conditions.

_____

_____

_____.

(4) Assess the utility of each control option.

_____

_____

_____.

(5) Assess the capability of the de-icing equipment to eliminate ice buildup during ground and airborne operations.

_____

_____

_____.